

**Performance Evaluation
of the
Midwest Research Institute
at the
National Renewable Energy Laboratory**

April 1, 2003 through September 30, 2003
Performance Period

Prepared
by the
Office of Energy Efficiency and Renewable Energy's
Performance Evaluation Board

January 6, 2004

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Critical Outcome 1.0 – Science and Technology: *MRI will deliver high quality scientific and technological outcomes that advance DOE priorities and Program objectives.*

NREL has performed in an overall outstanding manner in the area of Science and Technology. During the period MRI/NREL sustained its production of high quality and relevant science across all areas of its assigned mission. NREL research staff have actively engaged their academic, private sector, and public sector peers, both nationally and internationally, to independently and objectively examine and validate the quality of their work. NREL staff are sought to fill leadership roles in a wide-ranging set of private and public sector fora, and work collaboratively on common technical problems in teamed research initiatives with universities, industry, and other national laboratories to advance EERE's mission. These collaborative efforts continually earn high praise from critical industry partners. NREL continues to serve EERE as the technology bridge between research and development programs in support of such critical national initiatives such as EnergySmart schools and international initiatives such as resource assessment. During the period, NREL pursued and achieved its technical goals with distinction. Significant accomplishments include setting a world record for a monolithic two-terminal III-V solar cell and a prototype multi-junction thin-film cell. These accomplishments represent major steps toward satisfaction of the High Performance PV Initiative goals, viz., a 40%-efficient cell for a 33%-efficient III-V concentrator system, and a 25%-efficient multi-junction thin-film cell. NREL also demonstrated the capability of a new hydraulically actuated resonance test system, a major step toward viable low wind speed turbines. MRI/NREL led, or were critical participants in, numerous private and public sector research and development program planning fora offering expert and objective counsel to these parties thereby fulfilling its role as a Federally Funded Research and Development Center. In the technology transfer arena, MRI/NREL continues to influence the global state-of-the-art across its assigned mission areas through publication of numerous peer-reviewed papers, symposia, and other venues. NREL has created opportunities during this period of performance through their activities with various state governments in fostering partnerships that have led to collaborative activities. Through the licensing of the NREL developed Advisor Model they have obtained access to numerous industry developed combustion and emissions control computer codes that are of great value to the program. MRI/NREL has critically examined and, as a result, is refining its criteria for intellectual property management in an effort to improve technology transfer performance while maintaining, or even reducing, the costs of this vital capability. In the first full year of managing the combined Laboratory biomass program, NREL performed exceptionally in terms of integrating not only the AOP's from three areas, but also integrating the business management, tracking and technical management activities. The vast majority of all milestones were met on or ahead of schedule and adequate and timely notice and rationale for the few delays was consistently provided. Financial information was provided in a timely concise and meaningful manner. Further, NREL has become a valuable asset in coordinating the activities of all the EERE National Laboratories and in developing effective partnerships with them.

This Critical Outcome is rated "Outstanding".

1.1 Demonstrate the quality of scientific and technological outcomes.

Significant Achievements:

- Lamar Tall Tower Inflow Characterization. NWTC researchers established the role of low level jet occurring in the disk of Low Wind Speed Technology turbines and provided operating information to LWST turbine participants on design information. Successful characterization required resolution of a number equipment-related problems by NWTC staff. In addition, staff scientists from the NWTC, the National Center for Atmospheric Research and General Electric Company cooperating to measure wind velocities at the Lamar tower in eastern Colorado near the town of Lamar where GE has developed a wind farm. Results of the first week's deployment of the NCAR laser radar (LIDAR) have shown that the LIDAR can observe the existence of a low level jet that forms during the night at an altitude from 40 meters to 150

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meters above ground, where the blades are likely to be located on a wind turbine optimized for low wind speed sites. Turbine operation in this area can increase the fatigue damage to a turbine rotor and must be accounted for in new designs. Use of the experimental LIDAR allows rapid characterization of a site rather than installation of an expensive guyed tower. This is a major experimental breakthrough with critical implications for the wind industry and the program's highest R&D priority for low wind speed technology development.

- The DOE PV Subprogram conducted a Peer Review of the Thin-Film PV Partnership and PV Module and System Reliability activities on August 14-15, 2003. A total of 19 in-house and subcontracted projects, both NREL and SNL, were reviewed by a DOE-independent panel of six PV experts. The feedback from the panel will be used to justify PV Subprogram research priorities.
- On August 11-12, 2003, NREL conducted an in-depth peer review of seven university subcontracts supporting exploratory R&D in crystalline silicon PV areas identified by the U.S. PV industry. The peer review panel consisted of PV experts from several companies, and identified strengths and weaknesses in subcontracted research. This exercise was part of a program milestone to assess the impact of university collaborations with crystalline silicon companies.
- NREL and First Solar, Inc. (Toledo, OH) were selected for a joint R&D 100 Award for High-Rate Vapor Transport Deposition for CdTe PV Modules. The award is specifically for the DOE-NREL program that has developed a continuous-feed, automatic, nonstop production line for manufacturing cadmium telluride PV modules. The research has helped First Solar reduce the price of their product by 30%.
- NREL personnel presented an overview of the Fuels Technology Program to the National Advisory Council, which is chaired by MIT. The feedback from the Council was that the NREL program was well focused on the National goals of DOE and was supporting activities that are of great value to industry as well.
- The work in the area of Thermal Management was considered to be outstanding as reported to DOE from Ford Motor Company. The thermal management model is used by battery suppliers to design improved performance cells.
- NREL staff developed and participated on "Tiger Teams" which were of great value to natural gas vehicle stakeholders in helping them solve technical problems which arose in the field during the operation of natural gas vehicles.
- Technology evaluation projects managed by NREL were peer reviewed by the Freedom Car Tech Team on Systems Engineering and Analysis. Results of the peer review were favorable in the areas of: Hybrid/fuel cell modeling; Hybrid/natural gas trucks; and Medium duty hybrid trucks.
- All NREL projects reviewed at the 2003 DOE Hydrogen, Fuel Cells & Infrastructure Technologies Merit Review and Peer evaluation were highly rated by the reviewers.
- NREL published and presented the following peer-reviewed papers:
 - "Band-Edge Potentials of n-Type and p-Type GaN", J. D. Beach, R. T. Collins and J. A. Turner, Journal of The Electrochemical Society, vol 150, pp A899-A904 (2003).
 - "Preparation and photo characterization of Cu-Sb-Se films by electro deposition technique" A.M Fernández and J. A. Turner, accepted for publication in Solar Energy Materials and Solar Cells.

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- "Preparation and Characterization of Copper Indium Gallium Selenide Sulfide Thin Films from Electro deposited Precursors for Hydrogen Production" Jennifer E. Leisch, Raghu N. Bhattacharya, Glenn Teeter, and John A. Turner, accepted for publication in Solar Energy Materials and Solar Cells.
- Over the six month period, NREL has conducted three peer reviews of its R&D activities involving over fifty industrial participants. These reviews confirmed the direction and relevance of the majority of NREL's activities. In instances where a change of direction was indicated, they, with their other National Laboratory partners, implemented rapid and effective change in the activities. In addition over this period NREL researchers have authored a total of 24 peer-reviewed publications. Recognition of the Program's efforts as valuable by industry and academia is important in validating the direction of Program activities and in developing broad-based support for the Program.

Notable Achievements:

- An article entitled, "Boundary Layer State and Flow Field Structure Underlying Rotational Augmentation of Blade Aerodynamic Response," co-authored by S. Schreck and M. Robinson, has been revised in response to reviewer comments and returned to the Journal of Solar Energy Engineering for publication. In this article, turbine blade surface pressure data acquired during the NASA Ames wind tunnel test were analyzed to identify the boundary layer state and to quantify aerodynamic force production. Clear connections between boundary layer state and aerodynamic forces were discovered and characterized. These findings will form the basis for physics-based computational modeling of rotationally augmented blade flows, which will begin to alleviate some of the inaccuracies inherent in current low-order phenomenological approaches.
- The National Center for Photovoltaics (NCPV) staff members managed significant roles in the 3rd World Conference on Photovoltaic Energy Conversion in May 2003. Dr. L. Kazmerski, Director, NCPV, was the General Vice-Chair of the conference. Two presentations authored by NCPV staff members were given awards for "best papers" in the various program categories. Additionally, Ms. Juki Yoshida, a graduate student doing her Ph.D. research at NREL, was recognized as an "outstanding young scientist" for her work on transparent conducting oxides for polycrystalline photovoltaics.
- NCPV staff member Dr. R. Noufi is Chairman of the Fall Meeting of the Materials Research Society (MRS) for 2003. This is a major honor as the prestigious event attracts several thousand attendees from all over the world.
- NREL's accelerated weathering testing revealed the potential for degradation of a promising ultraviolet screen coating for low-cost polymer glazings. Glazings with a 2-mil thick UV screen coating began to show degradation at about 13 years of equivalent UV exposure. Identifying inexpensive materials that can withstand exposure to sunlight for at least 15 years is key to the development of a low cost solar water heater. NREL is now testing 4 and 6 mil thick UV screen coatings and believes 20+ year polymer glazing life is attainable. In addition, stress/strain testing demonstrated that the low-cost polymer absorber materials will retain their mechanical properties at elevated temperatures. Further testing also revealed that wet stagnation should present no problem for the polymer absorber materials.
- Several Spectrolab concentrating photovoltaic (CPV) modules were tested at the NREL High Flux Solar Furnace (HFSF). Efficiencies slightly over 30% were obtained, very close to test results at ideal laboratory conditions for a single cell. With further development in this area, Spectrolab will be in an excellent position to provide cells for CPV receivers.

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- NREL provided optical characterization assistance to the CSP dish industry using its unique Video Scanning Hartmann Optical Test (VSHOT) system. This assistance included testing dozens of Science Application International Corporation (SAIC) fixed focal length mirrored facets intended for use with Stirling or CPV receivers as well as Stirling Energy System's (SES) facet design intended for use with their 25kW Stirling systems.
- Both of NREL's low-cost solar water heater (SWH) development partners, Davis Energy Group (DEG) and FAFCO, Inc., built second-generation prototype polymer SWH's in FY03 after extensive testing and redesign of their first-generation prototypes. Recent field monitoring data has shown better-than-predicted performance (40% efficiency) for DEG's 2nd-generation prototype SWH. Data from FAFCO's prototype SWH has just begun to be collected. NREL provided careful and valuable technical guidance to both partners during the rating period.
- NREL, working with the Building America Program teams, assumed an active role in tracking and reporting the building integration research and development progress of the consortia in meeting the required 40-70% energy efficiency savings in new residences as reported to OMB. Competitively bid contracts were negotiated with five industry teams and projects were initiated. The NREL program managers provide good scientific support and improved their timely research and management reports. They have evolved new improved methods to measure energy savings by Building America contractors and to verify accuracy of actual energy savings.
- In FY02, NREL completed the ASTM protocols regarding durability testing requirements for electrochromic windows. In FY03, NREL continued to support this work and presented the new protocols to various organizations.
- NREL successfully selected and contracted with 4 subcontractors under the "Zero Energy Homes (ZEH) Energy Supply Systems Integration" RFP to initiate development of building integrated solar electric and thermal systems under Phase 1, Concept Generation/Exploratory Research. This exploratory R&D will result in a down-selection of the best contractors for phase 2 in FY 2004. In addition, NREL's Zero Energy Home contractor teams have successfully worked with the Building America Teams to assist homebuilders in designing marketable Zero Energy Homes, which cut the utility bills by at least 50%. In fact, a few ZEH subdivisions are under construction where all or a majority of the homes are marketable Zero Energy Homes. This is an excellent achievement as the minimum requirement was to build ZEH models—ZEH subdivisions are considered optional but extremely important to builder acceptance.
- NREL is developing a modeling package to optimize the combination of highly energy efficient technologies with renewable energy, principally solar electric and thermal, to create a new generation of homes that produce all the energy they need on an annual basis.
- In accordance with the strategies of the High Performance Commercial Buildings Technology Roadmap, conduct RD&D for advanced technologies that offer significant improvements in energy performance. NREL performs work for DOE on three strategies from the Commercial Roadmap.
- NREL completed detailed energy performance monitoring of six high-performance commercial buildings in FY 03 and prepared draft case study reports. Feedback on the actual performance of the buildings versus simulation modeling predictions will provide the basis of a lessons learned report in FY 04.

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- NREL developed, tested, and released Version 1.6 of Energy-10, a user-friendly, low-energy building simulation tool targeted at the early phases of the building design process.
- NREL led a task definition effort for new international collaboration through the International Energy Agency. The IEA Solar Heating and Cooling Programme Executive Committee accepted the task proposal and approved the new Task in June.
- NREL researchers arranged for independent testing of the fin-on-plate heat exchanger by Intertek Testing Systems (ITS). The results of ITS tests and similar tests agreed to within 10% of each other.
- A tool was designed and fabricated for punching individual tabs into fin surfaces. Two small three-row test articles were prepared, with 5 fins per inch and 10 fins per inch, and tested in NREL's transient test loop. Results showed ratios of heat transfer enhancement to pressure drop increase that is superior to louvered and wavy fins used by NREL's industry partner, Super Radiator Coils.
- In a continuing effort, fuels modeling and development is being conducted simultaneously with DOE programs focused on advanced internal combustion engine concepts leading to the development of fuels and engines in parallel to achieve the greatest possible benefits in engine efficiency and emissions reduction.
- NREL presented the following invited lectures:
 - "Using Life Cycle Assessment to Find Improvements for Hydrogen Production from Wind Electrolysis", at the American Society of Mechanical Engineering Technical Conference, Chicago, September 2-6, 2003.
 - "Renewable Energy Systems, Energy Storage and Hydrogen" at Ashland University as part of their 2002-2003 Environmental Lecture Series on "Energy, Problems and Prospects".
 - "Energy and Hydrogen, Today and Tomorrow", at Ashland University as part of the high school lecture series.
 - "NREL research on Photoelectrochemical Water splitting" Annex-14 Expert Meeting in Paris, France.
 - "Integrated Multijunction Photovoltaic/Electrolyte System for Water Photoelectrolysis", for the Gerischer Symposium at the International Electrochemical Society Meeting, Paris, France.
 - "Materials and Band-edge Engineering Approaches to Photoelectrochemical Water Splitting", at the XXIst International Conference on Photochemistry, session on "Solar Light Energy Conversion: from Artificial Photosynthesis Technology to Solar Cells", Nara, Japan.
 - "Investigations of heteropoly acids for inorganic proton conducting fuel cell membranes", at the XII International Materials Research Congress, Symposium on Solar-Hydrogen-Fuel Cells, Mexico.
 - "Nitride Semiconducting Materials for Hydrogen Production from Water and Sunlight via Photoelectrolysis" at the XII International Materials Research Congress, Symposium on Solar-Hydrogen-Fuel Cells, Mexico.
- NREL researchers continue to be recognized for their technical excellence as evidenced by selection for service on advisory committees and as chairs of scientific bodies and conferences. This is important to the Program as it provides a conduit not only for dissemination of government-funded research but also allows the Program to keep abreast of advances outside the program and to leverage activities of other institutions. The rate of patented discoveries continues to be high with 5 patents issued during this period.

Significant Deficiencies: None.

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Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s):

- NREL should continue its aggressive schedule of Gate (peer) Reviews. With decreased R&D funding, it is increasingly important that the work be tightly focused on key barriers as well as on appropriate industry needs.
- There is a concern that upon occasion there is a deficiency in communications with DOE staff and a lack of responsiveness regarding DOE direction.

1.2 Demonstrate excellence in program planning and management.

Significant Achievements:

- NREL management and staff led the effort to develop a multi-year technical plan using the new budget structure and drawing on industry's and customers' perception of the need for further research. The revised program was structured to demonstrate progress on attainment of the program's principal goals and resulted in a draft plan suitable for DAS-TD review by the end of the planning period. The result was an outstanding draft plan that clearly related research activities to program goals in a fashion that an informed layman could comprehend. In addition, NWTC's Financial Analyst was instrumental in preparing the FY 2004 Program Execution Plan and transferring that data to the new EERE Corporate Planning System. Without this extraordinary effort by NWTC staff and management, neither would have been possible with limited HQ staff resources.
- NWTC management and staff were instrumental in organizing and participating in the joint Peer Review Meeting, held for the Wind & Hydropower Program on June 24-25, 2003 in Washington, DC, that focused on strategic programmatic directions presented in the Multi-year Program Plans and a high level strategic review of ongoing RD&D activities. In addition to the independent peer review panels, the industry associations AWEA and NHA participated in the reviews and provided valuable feedback to the program. DOE and NREL were recognized for doing an excellent job of managing the programs.
- NREL Site Operations and the NWTC have supported the development of a strategy, plans, and associated briefings to explain the requirements and need for new Large Wind Turbine Test Facilities (70-meter blade test and 8 MW dynamometer test facilities) located at the NWTC.
- NREL has led the development of several significant planning documents for the Solar Energy Technology Program, including the first-ever Multi-Year Technical Plan for the Solar Energy Technology Program (Draft, August 2003). The NCPV also played a key role in the revision of the Photovoltaics Technology five-year plan, to be published in September 2003. Both planning documents are key in developing long-term R&D strategies.
- NREL staff supported a series of meetings with the Western Interstate Energy Board (WIEB), state economic and energy policy advisors in Nevada, Arizona, and New Mexico, and energy staff at the Western Governors' Association (WGA) annual meeting. The objectives of the meetings were to present an analysis of the economic, energy and environmental benefits of developing the state's solar resources and to solicit each state's interest in participating in the development of 1000MW of concentrating solar power systems.
- NREL has done an outstanding job in managing the Concentrating Solar Power subprogram. Budget cuts

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over the last three years have resulted in loss of staff and a reduction in technical contracts. During this difficult period, NREL has maintained a positive attitude and kept an excellent working relationship with both DOE and Sandia. It has continued to meet revised milestones and respond quickly and fully to the many requests made by DOE. DOE has reevaluated its position on CSP due in large part because of the NREL's and Sandia's efforts.

- NREL provided significant support in the development of a strategic plan for OWIP's international activities. Additionally, NREL provided technical assistance to Ghana in their development of a planning methodology and identifying an initial activity of replacing incandescent light bulbs with compact fluorescent fixtures which could result in the delaying construction of a conventional fueled power plant for a decade. The Ghanaian government is presently assessing various implementation strategies.
- Developing an integrated resource assessment methodology utilizing geographic information systems to provide preliminary assessments for developing countries and to prioritize activities to focus on high impact localities.
- NREL developed HVAC BESTEST validation test suite for building energy simulation models was recommended by the ASHRE Standing Standards Committee SSPC 140 for incorporation into ANSI/ASHRE Standard 140. A new follow-on task to IEA SHC Task 22 was approved by the IEA Solar Heating and Cooling Executive Committee for BESTEST case studies on ground coupling, multi-zone envelop modeling, and daylighting to support the ANSI/ASHRE standard.
- Assistance provided during development of the multi-year plan for Fuels Technologies was outstanding.
- All of the AOP goals of the battery storage support effort were met. A strong communication network with DOE and industry has led to effective partnering arrangements.
- Technology evaluation AOP milestones were all met. In addition excellence was demonstrated in planning future demonstration and modeling activities.
- For the HFCIT Program, NREL provided technical support to establish the RD&D agenda for the period FY04 - FY10 by recommending technical targets and milestones, designing technical approaches to overcome barriers, and designing and producing a draft multi-year RD&D plan for DOE. NREL also designed a change control process to manage the process of addressing comments on the plan.
- NREL lead the preparation of the first Multi-year Technical Plan (MYTP) for the integrated OBP Program gathering input from all program participants including all NBC labs, GO and NETL. The MYTP captures the nature, timing, and funding of the ongoing and anticipated technical activities in support of the goals and strategies laid out in the OBP multi-year program plan (MYPP). A significant contribution was the construction of the first work breakdown structure to include all OBP projects in a clear Program-wide framework. This MYTP provides a consistent and integrated structure and framework for managing Program activities and provides an outstanding communication tool for conveying the direction and goals of the Program.
- NREL coordinated the preparation of the draft FY04 OBP AOP that, for the first time, included all OBP projects expected to be active in FY04. NREL worked with all NBC labs, the Golden Field Office (GO), the National Energy Technology Laboratory (NETL), and OBP HQ staff to collect individual project information to include in the AOP. This consolidated AOP significantly facilitates management of the

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overall Program effort by DOE/HQ management and staff.

Notable Achievements:

- The effort of the new national team for thin-film module reliability, organized and led by NREL, has been expanded with the award of two new subcontracts from the NREL solicitation, “Thin Film Module Testing in Hot and Humid Climates.” All major U.S. thin-film companies are participating in the research, with modules submitted for testing at NREL and the universities.
- Working with Brookhaven National Laboratories, the NCPV’s Thin Film PV Partnership activated a new website to address ES&H issues associated with the use of cadmium in PV (<http://www.nrel.gov/cdte/>). The website helps to centrally locate key information on this important issue so that decision-makers at the consumer, manufacturer, recycler, or policy levels, as well as researchers in the laboratory, can make informed decisions.
- The NREL PV Program conducted several major solicitations during this period, including the “University R&D for Future Generation Solar Electric Technologies” solicitation, which is part of the new PV Science Initiative in the DOE PV Subprogram. These solicitations, based on peer reviews to establish R&D priorities, are intended to attract and select the best photovoltaic researchers in the United States.
- NCPV engineers surveyed six PV-powered, net-metered buildings in the Los Angeles area. User response was highly positive (provided the buy-down and other incentives were available), thereby helping to validate some of the input required for the PV Subprogram’s Systems-Driven approach.
- Based partly on validation testing conducted on stand-alone PV systems at NREL, the IEEE-SA Standards Board Review Committee approved IEEE P1526, “Recommended Practice for Testing the Performance of Stand-Alone Photovoltaic Systems,” as a new recommended practice. The new standard provides procedures that independent testing laboratories will use to evaluate the performance of stand-alone PV systems.
- The Solar Program has benefited substantially from funds allocated for renewable energy projects in Nevada. Solar related projects include projects related to CSP, PV, and one project related to a zero energy home using both PV and solar water heating systems. NREL has provided technical support to all of the funded efforts.
- In a joint activity, the Residential Energy Services Network (RESNET) and NREL continued the development of a common methodology to benchmark homes, on a national level, for determining residential building energy use improvements so as to quantify the program benefits and progress toward meeting national energy goals.
- Developed field testing plan for electrochromic windows in close cooperation with industry, LBNL, HUD, NAHB-RC, Building America, and other interested parties which is now being used. Awarded competition for Electrochromic devices.
- NREL and a Zero Energy Home (ZEH) contractor team worked closely with the National Association of Home Builders (NAHB) and its homebuilder, Pardee Homes, in designing the NAHB Show Home for the Convention in Las Vegas in January 2004. The Show Home, a 5000 sq ft Zero Energy Home includes: a highly energy efficient building envelope, Energy Star Appliances, many other energy efficient features, 7.5 kW of solar electric and a solar water heater. The Show Home was started in the summer 2003 and was

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completed in November 2003. The home will be featured in many builder magazines and visited by thousands of homebuilders and homeowners before, during and after the convention.

- Completed monitoring of six high-performance buildings projects and prepared draft reports for all six projects by the end of FY 2003.
- NREL and its subcontractor, Princeton Energy Resources, Inc., developed a number of geothermal analysis products. Principle among these was an economic evaluation of the cost and availability of water for evaporatively enhanced air-cooled condensers. Additional effort was placed on updating the geothermal model in the National Energy Modeling System.
- Chairing the roundtables on base fuels and blend-stocks at the fuels and combustion workshop was done in an outstanding fashion. The information recorded was directly used in the multi-year planning effort.
- Support received during the multi-year planning activity for natural gas activities was outstanding.
- Innovation was demonstrated in the technical negotiations of natural gas engine development contracts to ensure flexibility to allow for closer control during the life of contracts.
- NREL assisted DOE in defining the hydrogen-biomass scope by proposing the identification of "mutual technologies of interest" to the two DOE programs. NREL provided a draft chart of collaborative hydrogen activities across DOE spanning hydrogen production through use in both stationary and transportation applications. NREL led a joint effort between the Hydrogen, Fuel Cells, and Infrastructure Technologies and Wind Programs to study the opportunities for producing hydrogen from wind.
- NREL represented the U.S. providing the hydrogen expert to advise the Spanish Ministry of Science and Technology on its hydrogen research.
- NREL has initiated an effort to coordinate analysis activities across the Program and Laboratories and with PBFA. This is a significant challenge and was furthered by an analysis coordination meeting held in May and a subsequent analysis roundtable in July.

Significant Deficiencies: None.

Notable Deficiencies:

- NREL did not deliver the beta Version 2.0 of Energy-10 on schedule and did not notify DOE-HQ that significant technical difficulties would prevent Versions 2.0 from ever being released until months after the originally scheduled dates.

Items of Program Interest or Concern for the Next Performance Period(s):

- As recommended in the most recent Peer Review of the program, a single concept for enhancement of air-cooled condenser tubes needs to be selected for further development and technology transfer. NREL has been given the lead in managing and completing this process, which DOE would like to see completed by the end of February 2004.
- NREL should work on program metrics and outyear milestones so that they link and cascade to Program targets.

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- NREL should focus on thermal management issues associated with battery components (i.e. at the cell level) rather than full battery systems integration.
- A minor concern in the EPACT support area was that DOE would like NREL to be pro-active in their approach to outreach.
- NREL should continue its excellent work in leading the extension of Stage Gate Management to projects in the OBP portfolio.
- NREL failed to hold Empire Energy LLC, its subcontractor, to the agreement that had been reached among Empire, NREL, and DOE at a July 28th, 2003 meeting regarding the future course of the Empire Small Scale Field Verification project. That failure allowed Empire to digress by exploring several other options for the technology to be used in the project, causing a delay of four months and an associated increase in project costs.

1.3 Produce S&T accomplishments that advance DOE and program objectives.

Significant Achievements:

- NREL began testing of three advanced drive trains optimized for low wind speed applications. The advanced drive trains that are being developed under Low Wind Speed Technology public/private partnerships will be tested at the NWTC 2.5 MW Dynamometer test facility in FY 2003/2004.
- NWTC researcher Walt Musial and colleagues have developed a new hydraulically actuated resonance test system that was successfully tested in September. A linear excitation force was applied to the blade in the flap direction by oscillating a 1000-lb mass in the direction of motion. The excitation force is easily able to generate forces sufficient to drive the flap loading to 100% of its full scale level. Testing continued through the next phase to finalize the closed loop feedback control methodology and add conventional edge loading. The test levels were selected to match the force loading test that was started on the same test article in July. Following stable closed loop operation in the flap direction, an edge actuator will be added using a conventional bell crank system. This new method is protected under international patent treaty laws. Its key advantages over the current method include, faster test times (2x), lower energy use (66% less), and scalability to large blade sizes. This is a major achievement that will assist the program's low wind speed technology R&D effort.
- Under a cost-shared arrangement, a NREL subcontractor continued its remarkable progress in conversion efficiency records for a terrestrial concentrator solar cell, including the demonstration of a multi-junction cell with efficiency of 36.9%. This is a world record for a monolithic two-terminal solar cell.
- NREL staff contribute regularly and significantly to strategic planning discussions. Their contributions are thoughtful and insightful.
- Completed safety and performance assessment of E-Diesel.
- Completed study on weekend and weekday differences in ozone levels. This included co-authoring several technical papers that were published in Journal of the Air and Waste Management Association.

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- Completed long term durability testing of diesel particle filters, enabled by low sulfur diesel fuel. The results indicate that these filters when used in conjunction with low sulfur diesel fuel will allow diesel engines to meet stringent emissions standards and also meet the useful life requirement.
- Completed a study on the emissions characteristics of fuels produced from Canadian tar sands which concluded that emissions from these fuels are very similar to those from conventionally refined diesel fuel.
- Completed the evaluation of two diesel trucks optimized for use of Fisher Tropsch diesel fuel. The results showed that significant reductions of particulate matter and NOx were achieved as compared to similar vehicles using conventional diesel fuel.
- Issued a report on the results of a test that compared the use of hydrogen enriched natural gas to natural gas in heavy applications. The results indicate that significant emissions level reductions can be achieved by blending hydrogen with natural gas.
- Developed a class 4-6 drive cycle that will allow for a standardized test procedure for evaluating the performance of heavy hybrids.
- Identified technology needs of new and emerging technologies developed by OFCVT by testing and evaluating these technologies in vehicles under real world conditions.
- Significant progress has been made on two key barriers to cost-effective sugars stream from biomass, pretreatment and enzymatic hydrolysis. A high specific activity cellobiohydrolase was discovered that has the potential to decrease the cost of sugar produced from lignocellulosic biomass. High solids pretreatment of lignocellulosic biomass was advanced from 20% solids to over 30% solids which represents a potential reduction in fuel cost of \$0.26/gal.
- The enzyme subcontracts managed by NREL met or exceeded their cost reduction targets. Genencor exceeded its 10x enzyme cost reduction goal by over 10% and Novozymes met their intermediate goal of a 5x reduction. During the subcontract NREL worked closely with GCI evaluating new enzymes by testing them on real substrates, auditing production process improvements, and calculating cost reduction factors compared to the technology baseline using the bioethanol process model. This work satisfies the requirements of a DOE FY 2003 Annual Performance Target

Notable Achievements:

- An NWTC researcher has completed design of a wind turbine control system using modern state-space methods. These controls are designed to regulate turbine speed in operating region 3, while also attenuating blade response due to wind shear and enhancing the damping in the 1st drive-train torsional mode as well as the 1st tower fore-aft mode. These controls use independent blade pitch as well as generator torque control (to add damping to the drive-train). The designed controls show an improvement over controls designed using simple classical control design methods (such as Proportional and Integral control) and will be made available to industry on an expedited basis.
- Research proposed jointly by Prof. Roderick Galbraith (University of Glasgow), Robert Rawlinson-Smith (Garrad-Hassan and Partners, Ltd.), and Scott Schreck (National Wind Technology Center) has been selected for funding by the U.K. Engineering and Physical Sciences Research Council. This three year program is directed at developing and validating an enhanced model for predicting horizontal axis wind turbine dynamic stall. This capability will, in turn, allow more reliable design of wind energy machines by

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U.S. industry. This project will rely significantly on data acquired via the Unsteady Aerodynamics Experiment wind turbine during testing in the NASA Ames 80 ft x 120 ft wind tunnel. This is the first time a U.S. wind researcher has been funded by the European Commission and indicates the quality of the science involved.

- During the performance period NREL/NWTC continued its efforts to monitor and report on the performance of US-manufactured small wind turbines. The turbines are located in a number different climatic and geographic areas in the U.S. and are operated by various public and private entities who provide detailed information that enables a comparison of field operational data with data compiled on the same turbine models at the NREL-NWTC. During the performance period numerous test reports on three different turbine models were completed and made available to the public to serve as a valuable equipment assessment tool for potential users.
- NREL completed and tested a modified fin-on-plate heat exchanger with a new vapor distribution system as well as two new sets of fins. Laboratory tests show that heat transfer coefficients are higher by as much as 80% (at higher velocities) compared to tube and fin configuration.
- A heavy duty natural gas engine was developed under a contract that exceeded 2007 emissions standards and approaches the 2010 standards.
- Developed a joint thermal management plan for power electronics and electric machines.
- Modeling of heavy hybrid vehicles is recognized by the industry.
- Significant analyses were completed that will help set future Program direction in two new R&D areas, thermochemical production of intermediates and fuels (Thermochemical Platform) and conversion of biomass intermediates to products and chemicals (Products). A comprehensive study was completed in partnership with PNNL as an important first step in identifying the most promising, cost effective fuel synthesis technologies where biomass thermochemical conversion could have a significant impact. Over 300 potential process intermediates and products derived from biomass were evaluated and narrowed to the most promising 30 based on four screening criteria. The results of this evaluation will be used for more quantitative screening including market assessments and conceptual process designs to identify major technical barriers facing important bioproduct technology pathways.
- The DOE Hydrogen Storage Team is pleased with the hydrogen storage project at NREL. The PI, Mike Heben, is doing high quality research and is recognized worldwide as an expert in carbon-based hydrogen storage materials. He has been responsive to feedback and recommendations from DOE and the FreedomCAR Tech Team, and has established a comprehensive work plan to address reproducibility of experimental results - the primary technical issue for storage in carbon nanotubes (CNTs). Dr. Heben is one of very few researchers in the world who has fabricated CNTs demonstrating 8% hydrogen storage capacity. This accomplishment is notable, but has been met with skepticism in the scientific community because of the lack of reproducibility. His work plan addresses that skepticism head-on, and is part of a major go/no-go decision point for the DOE hydrogen storage activity in CNTs at the end of 2005. In addition, Dr. Heben has shown leadership in organizing the Carbon Working Group to address technical issues related to carbon-based hydrogen storage. His work in this area is critical to the DOE program and the President's Hydrogen Initiative as a breakthrough is needed to develop on-board hydrogen storage materials enabling 300-mile range within the weight and volume constraints of the vehicle.
- NREL showed that oxygen inactivation of hydrogen-producing algae can be limited by preventing oxygen

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accessibility through genetic engineering of the hydrogen-channel. By inserting a tryptophan side-chain, a physical barrier, or shield, is created that reduces the rate of oxygen diffusion into the active site.

- NREL designed a new system for continuous photo biological production of hydrogen by algae. Ten days of continuous production were demonstrated under sulfur-deprived conditions, more than doubling the production time of batch reactors.
- NREL demonstrated the production of hydrogen from complex waste plastics at the bench scale. Pyrolysis of polypropylene and catalytic steam reforming of the resulting volatiles over 10 hours produced hydrogen at 80 percent of stoichiometric conditions.
- NREL successfully tested a new support material for catalysts that resists: 1) attrition in a fluidized bed; 2) coking on the catalyst; and 3) formation of deposits at the point of injection of the biomass feedstock into the process. This allows gasification or pyrolysis of biomass to be extended for a significant period compared to previous technologies.
- Two materials, InGaN and GaPN, showed high stabilities for Photoelectrochemical Water Splitting, and all of the InGaN samples had the appropriate band edge potentials to split water into hydrogen and oxygen in acidic solutions. NREL determined that either of these materials has the possibility of reaching the DOE near-term 2005 goal of 7.5% efficiency and 1,000-hour lifetime.
- NREL completed the conceptual design for a 10x scale-up of the bubbling bed catalytic steam reforming reactor to 250-kg hydrogen per day capacity. This design will facilitate construction of a pilot-scale biomass to hydrogen system with better heat integration towards achieving the goal of 87% reforming efficiency.

Significant Deficiencies: None.

Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s): None.

1.4 Effectively communicate and transfer NREL-developed knowledge and technology.

Significant Achievements:

- Meetings of IEA Annex XI and Annex XX were held at the National Wind Technology Center. Annex XI aims to promote multi-disciplinary progress in wind turbine technology through cooperative research activities and information exchange. The Annex XI meeting dealt exclusively with wind turbine aerodynamics, and was intended to facilitate the exchange of recent turbine aerodynamics research findings. Annex XX was established recently to exploit turbine aerodynamics data from the NREL Unsteady Aerodynamics Experiment (UAE) wind tunnel test, and to provide improved wind turbine aerodynamics models for turbine design. The Annex XX kickoff meeting was held during May 7 - 8, formally inaugurating Annex XX. During this meeting, discussions were held concerning preliminary results and future plans in conjunction with the NREL UAE wind tunnel database. These two meetings were attended by over twenty aerodynamics experts from nine IEA member countries. Future meetings of Annex XI and XX will be held annually.
- NREL did an outstanding job developing the DER Education and Outreach materials including the DER Interconnection and Permitting Guide. NREL successfully completed DER technical assistance projects and actively followed up on past DER projects.

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- NREL exceeded its goals for technical assistance projects, supporting 163 federal EERE projects that will result in 500,000 kWh annually at Federal sites. NREL provided assistance to 43 onsite renewable projects and 9 renewable power purchases moving federal agencies to over 50% of the goal to obtain 2.5% of electricity from renewable resources.
- NREL coordinated the natural gas ALERT development and activities across all of the national labs and facilitated large utility energy savings contracts for GSA, Department of Commerce, and the National Institutes of Health.
- GT Solar, an equipment manufacturer located in Nashua, NH, licensed the NREL-developed PV Reflectometer technology and has initiated commercialization efforts. The PV Reflectometer is a patented, high-throughput, contactless technique that can measure surface roughness, AR coating thickness, metallization fraction and height, and backside reflectance in <1 sec. Developing strategies to transfer manufacturing-friendly diagnostic tools to the PV industry is a major milestone of the NREL PV Program.
- NREL expanded PPS coating testing to other sites and more rigorous conditions. The first test of 40-foot long tubes internally coated with PPS was started at Mammoth with exposure to production brine in June. That size tube is typically used in binary power plants and the ability to make a defect-free coating the entire length must be confirmed. PPS-coated steam vent pipelines at the Cove Point plant showed no sign of attack from acidic condensing steam after 14 months of service. Test of coated and uncoated tubes started at Puna, a high-temperature resource. A brine spray test of OMP-coated aluminum-finned steel tubing was started at Mammoth. This is the first test of the new OMP coating in exposure to brine spray. Tests of PPS-coated carbon steel pipe spools were started at a CalEnergy facility in the Salton Sea KGRA. The use of PPS-coated carbon steel well field pipe instead of problematic concrete-lined pipe could lead to major savings.
- The work of the NREL Legal Office in redesigning the laboratory's patent cost recharge program is a significant achievement because the new process gives programmatic staff a primary role in the decision whether to fund intellectual property legal work for obtaining new patents or maintaining existing patents. The new process provides the laboratory with a means for ongoing review of the patent portfolio and it will significantly reduce the use of indirect funding of patent and IP related expenses.
- NREL did an outstanding job developing the DER Education and Outreach materials including the DER Interconnection and Permitting Guide. NREL successfully completed DER technical assistance projects and actively followed up on past DER projects.
- NREL coordinated the natural gas ALERT development and activities across all of the national labs and facilitated large utility energy savings contracts for GSA, Department of Commerce, and the National Institutes of Health.
- In the thermal management area three technical papers were published by NREL personnel and presented at international conferences.

Notable Achievements:

- NWTC management and staff continue to provide active participation and effective support with modest resources to the National Wind Coordinating Committee, the broad based Wind Program stakeholder collaborative and the Utility Wind Interest Group that represents electric generation and transmission

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stakeholders. Building external networks of informed stakeholders is a key outcome of these activities.

- NREL produced excellent New Technology Demonstration Reports on Alternative Fuel Vehicles and Green Roofs.
- As part of the NREL-Solar Energy Center (SEC) Memorandum of Understanding (MoU), the 21-kW thin-film PV technology validation system has been fully commissioned at SEC, in New Delhi, India, with amorphous silicon, CIS, and CdTe thin film PV systems supplied by U.S. companies. The introduction of U.S.-developed technologies in major developing country markets provides important benefits to U.S. companies.
- NREL staff published three professional papers on its low-cost solar water heater technical support efforts and one paper on the potential for combined solar heating and cooling systems. NREL Solar Heating and Communications staff also developed a draft “Consumer Guide to Heating Your Water, Pool and Home with the Sun” that is presently undergoing solar industry and DOE Communications liaison review. In addition, an updated snapshot was recently generated for parabolic trough technology to include new information on parabolic trough technology developments. The new trough snapshot was also used as a test case to follow the new EERE publication guidelines and approval process.
- Specific informational tools developed by NREL staff have achieved industry accolades. These include the Fleet Buyers Guide – a source of technical information and specs for all alternative fuel vehicles, the station locator – information on location and operating specifics for all alternative fueling stations, and the mapping tool - a means to plan trips with alt fuel vehicles, are unique and essential tools for the alternative fuel industry. Each tool is easy to use and locate, responsibly maintained, and reliable.
- NREL is developing a solar powered desalination and pumping unit for brackish water. This activity can have a significant impact in areas with scarce potable water resources.
- There was a substantial effort to complete ammonia-water condensation experiments with the data transferred to Heat Transfer Research, Inc., for inclusion in their design codes. The most recent data transferred to HTRI is the process side heat transfer correlation for ammonia-water condensation at various inlet vapor concentrations.
- NREL participation with the Defense Threat Reduction Agency's Chemical and Biological Defense to transfer anthrax work and complete efforts.
- NREL began the initial development of an outreach effort to attract more participation by oil and petrochemical industry in NBC. They have established a dialog to find areas of common interest and potential partnership with 2 companies in this oil & petrochemical industry sector. Center Director delivered opening presentation (invited) at the National meeting of American Petroleum Institute in Denver, Sept 15, 2003.
- NREL hosted more than a dozen industry visits for the evaluation of R&D areas of mutual interest for potential collaborations, including: BOC Gases, Chevron-Texaco, Conoco-Phillips, Dow, Dupont, General Motors, Proctor & Gamble, UOP, and Westvaco. These are potentially important partners in broadening Program collaborations with industry.

Significant Deficiencies: None.

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Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s):

- NREL should aggressively pursue its outreach to the oil and petrochemical industry and other potential thermochemical partners (including the Forest Products Industry) with a goal of having at least one strong partner on board within the year.
- If CRADA's continue as a DOE and Laboratory business model, NREL should examine ways in which the time required for CRADA negotiation can be reduced.

Critical Outcome – 2.0 Leadership: MRI will lead NREL as an FFRDC to create opportunities that significantly advance the EERE mission while enhancing NREL's role as a recognized national and international asset.

MRI/NREL continues to be recognized as a world leader in many technical areas including wind, bioenergy, photovoltaic devices, materials, international standards, and reliability research, and is a source of expertise for EERE, academia, private industry, and the public sector. During the period, MRI/NREL's role as a Federally Funded Research and Development Center (FFRDC) was substantially elevated by EERE's designation as its systems integrator for the Hydrogen Program. The systems integrator role is critical to the success of the Hydrogen Program and the President's Vehicle Initiative, and MRI/NREL's selection as systems integrator reflects EERE's confidence that MRI/NREL can perform this function with distinction. MRI/NREL has already made significant contributions to the EERE Hydrogen Program even as it builds its systems integration capability. MRI/NREL continued its development of technical and entrepreneurial relationships with public and private sector in service of the EERE mission. NREL program leadership have become a key resource in the integration of all DOE Program-sponsored R&D activities. NREL has effectively created and led the Laboratory Coordinating Council. NREL has proactively expanded the National Bioenergy Center to include efforts at all national laboratories funded by the Program, in so doing turned the NBC into a functioning whole that will continue to be a significant resource for DOE and industry. Finally, MRI/NREL increased its productivity and its capacity to handle increasingly complex endeavors through its focused investment in professional training for its management and support staff.

This Critical Outcome is rated "Outstanding".

2.1 Provide technical leadership and input to the development of new opportunities.

Significant Achievements:

- During the period NREL was designated "systems integrator" for the DOE Hydrogen Program by EERE. In response, MRI/NREL organized and implemented a strategy to provide immediate service to the Program through reassignments of critical senior personnel while conducting a nationwide search for the best candidate to lead the integration effort. MRI/NREL's efforts have already brought clarity to the Program's scope and direction through implementation of systems integration discipline. If fully successful, NREL systems integration competency will serve as a model for other EERE programs.
- NREL has worked hard developing the analytical basis for the short-term, mid-term, and long-term goals of the Solar Program in support of the Systems Driven Approach. The systems driven approach is a philosophy being implemented by the Solar Program and is a priority. NREL is working closely with Sandia to develop a solar version of Advisor, a computer model for solar systems that will become the basis for the systems driven approach. During the rating period, NREL worked on the concept development and software platform evaluation as well as developing a preliminary framework/mock-up for the Solar Advisor

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user interface.

- On short notice, NWTC management and staff prepared background material and conducted original analyses to estimate off-shore U.S. wind resources and estimated cost of development in these shallow and deep waters. The result of this effort was to support further consideration of an expansion of the wind program to support U.S. industry in a potentially new area.
- As part of the Wind Program's exploration of off-shore wind technology, NWTC hosted its 2nd offshore wind workshop - Dialogue on Offshore Wind Development Issues in the U.S. - in Washington, DC on July 1-2. The workshop was intended for the stakeholders of offshore wind development projects and officials from the relevant federal government agencies.
- NREL wind program staff provided critical support that enabled EERE to deliver on its commitment to assist USDA in its implementation of key program activities under the Farm Bill of 2002, specifically Title IX, Section 9006, Renewable Energy and Energy Efficiency Improvements Program. NWTC staff helped craft the implementation plan for Sec. 9006, providing guidance on appropriate technical criteria to be used to determine funding requirements. Staff also participated in technical, market, and policy briefings on wind technology for key USDA staff both at the Headquarters level and all 50 USDA state offices. Staff served on the DOE-Lab Technical Review Team and provided expert analysis on technical viability of over 35 applications for funding within an extremely short time frame. This contribution led to over \$7 million in funding from USDA for 37 large and small wind projects across the country, including those in target states with no current wind projects, like Idaho. This contribution was officially recognized by EERE management in correspondence to NREL management.
- The MRI Internal Audit Department implemented two initiatives during the rating period enabling them to work better, smarter, and faster. MRI Internal Auditors now have electronic access to NREL's source documents and financial records. This electronic access should result in more efficient use of auditor's time and less burden on NREL staff to gather and copy this information, thus, working better and faster. MRI Internal Audit also implemented a revised risk assessment model for planning future audits. This risk assessment model should result in audits of the highest-risk areas to DOE and NREL, thus, working smarter and lowering NREL's overall management risk.
- Identified, organized, and presented to the fuels cross-cut team a proposal for how the natural gas activities could be of benefit to the hydrogen activity. This led to a collaborative effort being negotiated between the natural gas and hydrogen activities.
- Simulations performed by NREL personnel using Advisor model have been critical in identifying future program direction for several OFCVT activity areas.
- NREL worked closely with the DOE Hydrogen Program manager and with the EERE DAS to launch the effort to establish a systems integration capability at NREL that will initially be applied to the Hydrogen Program and ultimately to other programs in the EERE portfolio. This effort was launched in early May in a meeting with EERE and GO principals, MRI, and NREL executive management.
- NREL staff have participated in numerous national forums at the executive level that relate to the use of biomass. These included:
 - A Chief Technology Officers Conference co-sponsored by the American Chemical Society & BIO at which participants focused on the growing importance of biotechnology and biomass as the

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conversion technology and feed stock for the chemical industry of the future. The theme was on R&D partnering arrangements.

- The 3rd Energy Forum in Washington, DC hosted by NREL, DOE, and the U.S. Agency for International Development (USAID). The Forum focused on analytic issues and their importance to the nation's energy efficiency and renewable energy programs.
- The 25th Symposium on Biotechnology for Fuels and Chemicals chaired by NREL.
- Executive Board Meeting of the California Biomass Collaboration. This collaboration, sponsored by the California Energy Commission, will enhance the development of biomass energy systems in support of Renewable Portfolio Standards implementation.
- National Defense University's Future Energy Resources Workshop – Biomass, Ocean, Hydrates, and Hydrogen. The objective of the National Defense University workshop was to allow DOD to develop a better understanding of the current and future energy resources with reference to the roles of economics and global and national geopolitics. Deliberations at these workshops provide recommendations for DOD on future energy issues.

Notable Achievements:

- NREL worked with DOE to arrange a joint wind, hydropower, and hydrogen meeting with industry members and key stakeholders on the subject of the production of hydrogen by electrolysis using wind and hydropower, held in Washington DC on September 9-10, 2003. The meeting helped demonstrate DOE's commitment to the production of hydrogen from renewable energy sources and allowed the sharing of plans and analysis results between the industry, DOE programs, and the National Laboratories. This meeting is the prototype for a planned series of meetings with other renewable energy industry members to obtain input on the path forward for hydrogen production from environmentally clean energy sources. One immediate outcome of the meeting was that the industry members felt that the exchange of information was so valuable that they would like to continue to dialog at six-month intervals.
- The HOMER Version 2.0 software was publicly released. This version models a wide variety of renewable energy systems, including grid-connected systems. Homer has become a key component in the NCPV's international technical assistance programs in renewable energy in developing countries. NREL, through NCPV support, is taking the lead to develop a new 1971-2000 National Solar Radiation Database.
- NREL staff have lead the technical assistance activities for the formation of GPW state working groups in Hawaii and Alaska, and continues to provide support for GPW groups in Nevada, New Mexico, Oregon, Utah, Arizona, and Idaho.
- An NREL staff member held the position of chairperson of the APBF DEC steering committee.
- NREL personnel chaired technical working groups that operated under the APBF DEC Steering Committee.
- In a continuing effort, NREL coordinated U.S. participation in an information exchange with Japanese and European programs through the series of meetings agreed upon by the three parties.
- NREL completed analyses of 1) distributed methanol reforming for hydrogen delivered at lower cost to customers at fueling stations; 2) the water gas shift process, indicating limited economic potential; and 3) the continuous production of hydrogen from algal photobiological processes. The Lab provided the hydrogen analysis group, H2A, reporting and cash flow analysis spreadsheets for use in FY04 efforts, as well as economic analysis for inclusion into technical target tables in the Hydrogen, Fuel Cells and Infrastructure Technologies' multi-year research, development, and demonstration plan. The Lab conducted analysis on integrated wind/hydrogen systems, including component modeling and market adoption, and

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expanded earlier analyses to incorporate new data on hydrogen production from biomass. A technology brief on the ways in which to produce hydrogen from biomass was developed, delivered to the Biomass Program, and used in stage-gate analysis and review. These efforts greatly assisted EERE in the analysis and planning for future program direction.

- NREL worked with DOE to arrange a joint wind, hydropower, and hydrogen meeting with industry members and key stakeholders on the subject of the production of hydrogen by electrolysis using wind and hydropower. The meeting helped demonstrate DOE's commitment to the production of hydrogen from renewable energy sources and allowed the sharing of plans and analysis results between the industry, DOE programs, and the National Laboratories. This meeting is the prototype for another planned series of meetings with other renewable energy industry members to obtain input on the path forward for hydrogen production from environmentally clean energy sources. One immediate outcome of the meeting was that industry members felt that the exchange of information was so valuable that they would like to continue to dialog at six-month intervals.
- NREL Technical Leadership in IEA. NREL provided several leadership positions for the United States under the International Energy Agency's Agreement on the Production and Utilization of Hydrogen, including Annex 14, Photoelectrolytic Production of Hydrogen, Annex 15, Photobiological Production of Hydrogen, Annex 16, Hydrogen from Carbon Containing Materials, and Annex 17, Solid and Liquid State Hydrogen Storage Materials.
- DOE's Joint Genome Institute accepted NREL's proposal to finalize DNA sequencing of genes involved in hydrogen production. With understanding of active genes, NREL will transfer the oxygen-tolerant hydrogenase into other organisms for hydrogen production from a variety of feedstocks.

Significant Deficiencies: None.

Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s):

- The Program is interested in working under a CRADA agreement with NREL and Solar Systems Ltd. to develop cells for near-term concentrating photovoltaic dish applications.
- As the Program continues to prioritize limited resources, NREL will be challenged to continue as an honest broker of broad Program interests in its role as leader of the NBC and LCC.

2.2 Demonstrate leadership in building strategic partnerships that leverage resources and advance DOE priorities.

Significant Achievements:

- NREL staff supported the Program in its efforts to facilitate the use of concentrated solar power. During the period, NREL met with several Southwestern States and a number of organizations related to that region of the country (e.g., Western Interstate Energy Board and Western Governors Association). These meetings have educated policy makers of those states to the significant potential benefits of concentrated solar power (CSP). Largely through NREL efforts, four states (CA, NV, NM, and AZ) have agreed to look at the feasibility of a 1,000 MW solar power plant. They proposed that each of the states would purchase a portion of the power. Should such a plant be built, it would result in a significant decrease in the cost of solar power. The relationship with these states is thus very important to the Solar Program. NREL is a key component to that relationship.

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- Working in collaboration DOE's other national laboratories, NREL-led an initiative to make the laboratories more accessible by the states with EERE's Regional Offices serving as the focal point for energy portfolio standards, use of renewable energy on state lands, and deployment of EERE-developed technologies. The Office of Weatherization and Intergovernmental Programs was a key facilitator of this initiative.
- NWTC staff met with representatives of the Bonneville Power Administration, Western Area Power Administration, California Energy Commission, Southern California Edison, Xcel Energy, Electric Reliability Council of Texas, PJM Interconnection, Avista Utilities, and other stakeholders to provide technical information on the integration of wind energy into electric power systems. NWTC staff also supported the Utility Wind Interest Group, National Wind Coordinating Committee and diverse Wind Powering America meetings. NWTC staff work is continually lauded by the AWEA and is recognized as authoritative in the international arena.
- NREL is developing strategic partnerships with the other labs and international organizations to more effectively support the OWIP international mission.
- Participated as a chairperson of the APBF Steering committee which is the managing body of a large industry/Government research consortium. The work supported by this group is critical to the Program's mission.

Notable Achievements:

- NREL staff have made significant progress in forming alliances with other Federal agencies (specifically EPA and FHWA) to further our respective goals. NREL staff have developed effective strategies to combine financial resources at other agencies with the human resources in our 80 Clean Cities coalitions nationwide to reduce harmful emissions (EPA and FHWA mission) and increase petroleum displacement (DOE mission). This has been a very significant and productive undertaking.
- In collaboration with numerous support agencies such as AID, UNDP, and the World Bank, NREL provided technical assistance to South and Latin American countries to develop rural energy plans and development strategies that include renewable energy.
- A notable local project development effort in support of the EERE mission involves working with Jefferson County, USDA and several Colorado Front Range organizations to determine the feasibility of using modular biomass systems to reduce the danger of wildfires. The systems would produce either electricity or transportation fuel and help offset the costs involved in clearing the forests of excess underbrush and dead trees. If successful, the technology could be useful for reducing the potential for wildfires in much of the West. The NREL Legal Office was instrumental in facilitating the Bioenergy Center's participation in this project through negotiating a multi-party Memoranda of Understanding and Letter of Intent. Their effort is notable because it strengthens the Bioenergy Center's relationships with Jefferson County, local organizations and the USDA through cooperation in developing new sources of renewable biomass energy while reducing forest fire risk.
- NREL's efforts in Wind Powering America continue to build partnerships at the national, regional, and state levels across a variety of sectors including the public and private energy industry, agricultural, environmental, and other key stakeholder communities. During the reporting period NREL's Wind Powering America team (NREL/WPA) developed and implemented the Wind Powering America State Summit meeting between DOE program managers, industry representatives, and state-level officials and stakeholders. NREL/WPA staff also developed supporting materials including the landmark State Wind Working Group Handbook, a central repository for state officials on all aspects of wind technology and

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project development. NREL/WPA also led the development of a focused, national agricultural-sector wind outreach effort, establishing new contacts among national and state-based rural/farm associations, financial community, rural economic development organizations, and others. Staff attended over 20 conference and outreach meetings, providing direct technical and market information, as well as provided direct expertise to stakeholders on an almost daily basis.

- Sustained efforts by NCPV researchers in developing advanced transparent conducting oxides have placed NREL in a leading role in this increasingly important class of materials. These materials will have very important applications not only in thin-film solar cells, but also in solid-state lighting, organic electronics, and other electrooptic products. As a result, NREL is receiving a flood of interest to partner in developing photovoltaic and light-emitting devices.
- Work For Others (WFO) agreements were established with USAID (Sri Lanka and the Maldives) and the United Nations Environment Programme (the Solar and Wind Energy Resource Assessment Project) in international solar resource assessments. These WFOs demonstrate the value that NCPV-supported technology offers to other countries. The projects will assist U.S. industry in identifying markets abroad, and demonstrate strong leveraging of funding resources. NREL also established an MoU with NASA for sharing of data and scientific expertise that could lead to the use of NASA-derived satellite data products for value-added solar resource assessments specifically designed to assist U.S. industry.
- NREL and its Zero Energy Home (ZEH) contractor teams are very involved with the National Association of Home Builders Annual Meeting in both designing 2004 Show Home, a Zero Energy Home and participating in a full session in the Annual Convention. DOE's Assistant Secretary will be participating in the various events surrounding NAHB's Show Home.
- The NBC continues to be very active in a variety of Technology Partnership Agreements and Work for Others agreements. These have attracted over \$2 million in private and other DOE R&D funding to leverage the efforts of the OBP Program. Another 11 agreements are in negotiation that total over \$74 million in non-DOE funding.
- NREL continues to be active with USDA including partnering in technology projects and by involving them in Program strategic planning activities. NREL also continues to developing strong partnerships to be formed with industry, esp. Agri-processing and Chemicals.

NREL organized and co-chaired with the Air Force Office Scientific Research, the Workshop on Biohydrogen, Molecular Biomimetic Systems, and Artificial Photosynthesis for H₂ Production in April.

Significant Deficiencies: None.

Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s): None.

2.3 Develop NREL's leadership competency.

Significant Achievements:

- NREL assessed the vulnerability of critical Laboratory positions and associated core competencies. This effort was undertaken to ensure the continuity of leadership and developmental opportunities. Based on the

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leadership competencies, career development and a talent management strategies were developed. This will provide a consistent and progressive leader competency model. The model provides a benchmark for valued performance behaviors. Management development is critical for managers to effectively manage and develop human and organizational capabilities.

- The Learning and Development Team also drafted and presented to Executive Management core leadership competencies. These will be used in the future to further refine executive training and succession planning.
- MRI/NREL's long-term strategy of investing in the development of employees' skill-sets has increased productivity in some support functions and has provided a climate for creativity and innovation. Over the past years, NREL's indirect (support) costs has remained low as employee productivity has increased. Much of this increase is attributed to employees applying enhanced skills, provided through training investments, to remaking NREL's processes and procedures. Further, employees expanded skill sets have significantly contributed to the NREL support function's ability to consider more complicated issues and to knowledgeably counsel management on these issues. This far-sighted approach is laudable, with benefits accruing to EERE daily.
- During the period NREL hired a key individual to enhance NREL's capabilities in technology transfer. This individual's private-sector experience and national recognition will contribute to MRI/NREL's technology transfer leadership and the entrepreneurial spirit of the Lab. Combined with the NREL Legal Office's study of intellectual property management, MRI/NREL is poised to refine and invigorate its technology transfer mission in support of both EERE and NREL's long-term viability.
- NREL has made some key hires in support of the Fuels Technology activity. These hires possess the required expertise and National reputations to strengthen the capabilities of the Re-Fuel Laboratory to become a premier fuels test and research facility for heavy duty engines and vehicles.
- The NBC at NREL was restructured to a flatter organization and staff was consolidated into fewer buildings which has facilitated more effective and efficient management and leadership and significantly assisted in the integration of formerly separate activities and organizations.
- The NBC was expanded to include all Program-sponsored Labs and the Laboratory Coordinating Council established to facilitate cooperation, coordination and communication. The LCC has been effectively and efficiently lead by the NREL Technology Manager.

Notable Achievements: None.

Significant Deficiencies: None.

Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s):

- DOE is anxious to work with MRI/NREL to examine strategies to enhance the relevance of its technology transfer contribution to EERE and NREL long-term viability.
- Program support that effectively advises DOE in managing technology research needs improvement. Resource leveling and work prioritization needs improvement. For example, critical areas such as economic analysis did not meet DOE objectives due to ineffective resource allocations. Appears to be too many managers on top of the research which impacts responsiveness.

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Critical Outcome – 3.0 Technical and Scientific Viability: *MRI will ensure the long-term viability of the Laboratory by building and enhancing NREL's technical capabilities.*

MRI/NREL management has anticipated and developed the core competencies, facilities, and staff capabilities necessary to ensure the vitality of NREL's scientific and support infrastructure, and its availability, to service the current and future EERE mission. During the period, MRI/NREL completed the Science and Technology Facility design through a broad and effective collaboration of research staff, NREL support staff, and federal staff. Completion of this project, scheduled for FY 06, will provide the nation the capability to advance its leadership in manufacturing of photovoltaic materials in the short-term and will dramatically increase NREL's ability to influence the direction of numerous EERE's program goals through advanced scientific understanding in the long-term. NREL's investments in discretionary research, while relatively small, have leveraged the EERE research dollar to produce innovations and ideas that advance EERE's mission and increase NREL's institutional vitality and viability. MRI/NREL's investment in long-term skills-needs planning and associated educational investments in its workforce guarantee that NREL will continue to lower its cost of operation through improved productivity and will have an available cadre of potential managers with current skill sets from which it can draw to fill future critical vacancies.

This Critical Outcome is rated "Outstanding".

3.1 Build, enhance, and sustain NREL's scientific, engineering, and analytic capabilities.

Significant Achievements:

- Over the past few years MRI/NREL has worked to establish its Director's Discretionary Research and Development program as a strategic resource for EERE and a contributor to NREL's long-term vitality. Through the application of a peer selection process, NREL has successfully targeted its DDRD funding to anticipate EERE's programmatic needs and to pursue high-value but high-risk science. In FY 03, for example, approximately 41% (~\$1200K), 31% (\$900K), 12% (\$360K), and 12% (360K) were allocated to 26 projects supporting the broad categories Bioenergy/Biotechnology/Chemistry, Advanced Materials, Advanced Measurement/Characterization, and Hydrogen Production/Storage/Delivery. While relatively small (~\$3M annually on a cost base of \$230M+), the program provides NREL staff the opportunity to investigate break-through technologies, is a source of new Lab capabilities in service of the EERE mission, helps to attract and retain critical scientific talent, and provides opportunities for private/public sector collaborations. Further, the DDRD program is a source of revitalization for NREL's scientific staff and is a key component in maintaining NREL's scientific vitality to meet EERE's future needs.
- During the period NREL initiated, developed, and implemented a number of capabilities to service EERE's long-term mission needs. These capabilities include, but are not limited to: Development of the Biomass Surface Characterization Laboratory; Enhancement of its Computational Sciences capabilities; Diagnostic capability for characterizing nanostructure matter; and the Single-Crystal X-Ray Diffraction Facility. These scientific capabilities, many developed through the Director's Discretionary Research and Development Program, in addition to other capabilities developed by MRI/NRE, provide EERE the cutting-edge scientific capability it requires to meet its current and future mission goals.

Notable Achievements:

- During the period NREL completed its *General Development Vision* document. The document, which outlines long-term (25-year) development assumptions and general guidelines for DOE's South Table Mountain and National Wind Technology Center sites, represents a collaboration between the private sector, and NREL, and DOE personnel, was well considered and will be relevant to EERE's future site development decisions at NREL.

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- NWTC staff have added networking software to pool 39 processors on desktops that can be used for extended computation to provide tens of thousands of hours of computer time for Statistical Loads Extrapolation studies to support the Low Wind Speed Technology project. Using the 50 processor computing cluster, NWTC staff computed a year's worth of turbine simulations (over 43,000 10-minute simulations) in a record 26 days, four hours, and four minutes. Without the processor pool, these simulations would have taken over 19 months to compute on a dedicated dual processor machine. This effort is an good example on how MRI/NREL can leverage existing resources in support of the EERE program.

Significant Deficiencies: None.

Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s): None.

Critical Outcome – 4.0 Mission Support: *MRI will manage and enhance NREL business and management systems, work processes, and capabilities to provide an effective and efficient work environment that enables the execution of NREL's mission.*

During the period, NREL administrative support functions performed admirably in the execution of EERE's mission at NREL. NREL continues to provide EERE the most research per dollar as measured by the Department's *FY 02 Support Cost by Functional Activity Report*, for the second year running. NREL functional support continue to enhance its management advisory capabilities providing management technical advice on critical issues allowing NREL to invest its resources effectively and to avoid both current and future problems. NREL's focus on measuring and publishing its functional performance in its annual *Business and Operating Results Report* as earned NREL a "best management practice" designation from the DOE's Laboratory Operations Board. Overall, NREL's business management personnel and practices continue to improve, provide superior value to EERE, and support EERE's programmatic mission at NREL.

This Critical Outcome is rated as "Outstanding".

4.1 Deliver efficient, effective, and responsive business and operational support.

Significant Achievements:

- The partnership between NREL HR and the NLO concerning a number of sensitive employee and personnel matters has produced effective and efficient business operations. Working together with HR, the NLO has provided proactive employment law advice and counsel, insurance policy administration and claims assessment to address employee and personnel matters in a cost effective manner. NREL's successful use of alternative dispute resolution processes in employee matters has significantly reduced outside litigation costs and efforts. NREL continues to avoid contentious employment lawsuits.
- NREL developed and implemented a substantially streamlined system for updating subcontract terms and conditions. This effort, requiring the participation and support of many NREL support functions, allows for automatic and real-time changes to subcontract terms and conditions thereby avoiding the expenditure of legal and subcontract staff on this largely administrative and labor-intensive activity. Further, the real-time inclusion of the most recent terms and conditions in subcontracts reduces NREL's overall risk exposure.
- NREL Vehicle Management has consistently provided a number of reports, data as well as a reduction

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schedule for an 8% reduction of the fleet. NREL's Vehicle Management Group has continued their proactive interactions in efforts to fulfill the reduction in fleet and has met the goal ahead of schedule. This commitment required substantial cooperative efforts given the already minimized vehicle fleet at the site.

Notable Achievements:

- Effective management of preventive, predictive, corrective, and deferred maintenance for facilities provides for a safe and reliable work environment for both office and laboratory workers. During the period NREL commissioned and completed a Condition Assessment Survey (CAS) to independently assess the condition of EERE's physical infrastructure investment at NREL. This effort will allow EERE to develop an efficient and focused reinvestment model for maintaining its strategic physical assets at NREL.
- NREL continues to demonstrate leadership concerning energy management and renewable energy technology implementation. Energy Management Agreement requirements for FY 2003 have been exceeded for water conservation with a 24% reduction from the baseline year of FY 2000 and an energy reduction of 4% from FY 2002.
- NREL Information Services successfully continues to maintain a sound cyber security posture by responding quickly to security advisories and having only three minor security incidents throughout the entire campus during this rating period.
- NREL library services defined metrics that will provide collection data on publications access as well as use of networked resources and cost benefit analysis of resources and services provided to the Laboratory.
- In the area of Records Management, NREL IS developed metrics for tracking transactions at the Federal Records Center and Joyce Street Facility and also tracking the percentage of Record Inventory and Disposition Schedules (RIDS) completed versus planned. NREL Integrated Business Systems developed metrics to begin tracking major development projects and implemented software to track production process and software service requests. By developing these metrics, NREL can begin to focus on areas of improvement by analyzing the newly developed metrics and making adjustments as necessary.
- NREL improved its performance subcontract placement and subcontract close-out through the Make/Buy program. As a result of a Make/Buy analysis, NREL obtained skilled private sector help for both its close-out and cost/price analysis functions. This expanded and focused capabilities were critical to the successful implementation of the late-funded FY 03 program and to the recovery of program dollars.
- NREL continued to meet or exceed its Balanced Scorecard Goals. Preplanning efforts played an important role in mitigating the impacts to subcontract awards of delayed funding. NREL's subcontracting goal of \$108 million was exceeded by \$11 million. This was particularly notable given that C&BS staffing was at below normal levels throughout much of this FY03 due to medical and Reserve Duty reasons.
- NREL has developed a very sophisticated Requirements Management System. The new process documents accountability, requirements flow down, and the lifecycle of each operating and administrative requirement. NREL benchmarked the system against the PNNL system that was recently identified as a best practice by the Laboratory Operations Board. The system was tailored to NREL business processes.
- NREL's market-based salary planning process and the integration of this process with the appraisal process has bolstered NREL's ability to attract and retain the scientific and support talent necessary to ensure

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NREL's long-term viability at the lowest reasonable price. This effort ensures that NREL's salary monies are applied strategically, ensures fairness across the scientific and support disciplines, and enhances NREL's desirability as a regional employer.

- A revised Personal Time Off Program was developed after careful analysis of various personal time off options. The new Personal Time Off Program will provide employees greater flexibility in the use of leave and contribute to a comprehensive and cost effective benefits program. Productivity improvements should be realized from the program's implementation.

Significant Deficiencies: None.

Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s):

- NREL needs to use a conservative approach to project development and management to ensure that all capital projects meet the Department's expectations regardless of project value. The upcoming construction of the Science and Technology Facility will be of significant interest to internal DOE as well as external parties, and NREL must be prepared to operate in this transparent and demanding environment.
- The Field Office will be interested in efficiencies and productivity improvements resulting from the implementation of the new Personal Time Off Program.

4.2 Build and enhance NREL's business and operational support capabilities.

Significant Achievements:

- The Sustainable NREL Master Plan continues to provide an outstanding roadmap for saving energy and establishing an example for energy management at DOE. NREL received the 2003 Department of Energy Management Award for outstanding achievement in energy and water management. A major contributing factor was NREL's implementation of four best management practices for water conservation as well as its dedication to funding energy efficient projects.

Notable Achievements:

- NREL completed a Benefits Value Study in late FY 03. The study benchmarked NREL benefits to industry participants approved by DOE. The results of the study will facilitate the development and refinement of employee benefit programs and contribute to the achievement of objectives and business strategies in support of NREL's mission in a cost effective manner.
- NREL completed a Diversity Program Assessment. Activities were identified to further strengthen NREL's Diversity Program. The Program and enhancements further contribute to NREL's ability to attract and retain a diverse workforce enabling the Laboratory to meet its vision and mission.
- A Telecommuting Pilot was initiated. The Pilot will enable NREL to assess the impact of telecommuting on such areas as safety and health, productivity, value as an employee benefit, and security.
- During the evaluation period, the NREL Finance Office continued their efforts under the four major Finance Initiatives jointly agreed by the Golden Field Office and NREL. These Initiatives were developed from the President's Management Agenda and have resulted in: more timely and targeted training, (Strategic Management of Human Capital); improved cost savings resulting in more program dollars more quickly available (Improved Financial Performance); timely and accurate cost reporting and project closeout

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(Budget and Performance Integration).

- Early in the period, the NREL Finance Office lead the effort to plan and complete closeout of work funded with Limited Term (FY 1998 Single Year Appropriation "Y-8") funds. This resulted in closeout of all Y-8 funded work without any loss of Program funding and also set the path for continued management of limited term appropriations.
- During the period, the NREL Finance Office proactively worked to resolve a major discrepancy between the contractual records and records in the DOE Finance system. NREL produced data leading GO and NNSA to review the DOE financial system information, identify a major system error thereby resolving the discrepancy. This has enabled DOE to proceed with closeout of the past M&O contract.

Significant Deficiencies: None.

Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s):

- Due to injuries and required military service NREL procurement functioned during FY03 at a cost-to-spend ratio of 2%. This is actually at 80% of the Balanced Scorecard Goal and is probably too low to properly complete the C&BS mission for any prolonged period. Two additional factors that increase my concern include: 1) as of the end of December the group will lose its Director; and 2) an IG audit of the Group was completed this summer. The final report has not been issued, however during the exit conference the IG team while being complimentary overall mentioned their concern about the subcontract closeout backlog.

Critical Outcome – 5.0 Environment, Safety, and Health: *MRI will protect the safety and health of the NREL workforce, the community, and the environment.*

NREL continues to be a performance leader in the environment, safety, and health arena. Through the leadership and hands-on participation of MRI/NREL management, NREL has established a culture of risk identification and management that employs risk avoidance and/or mitigation strategies. This approach, combined with comprehensive staff training, the adoption of external standards, and constant performance assessment and benchmarking, has placed NREL among the best environment, safety, and health performers among the DOE national laboratories and similar private sector businesses. Moreover, NREL has been able to maintain this sustained superior performance despite the reduction of staff and the increased responsibilities associated with the design of the Science and Technology Facility (S&TF). During the period, NREL completed the comprehensive environmental assessment of DOE's South Table Mountain site thereby making informed decisions regarding site development and operations possible. Additionally, NREL supported the environmental needs of EERE programs executed at NREL. NREL's continued integration of its Environmental Management Program with the Sustainable NREL Program contributes to effective site-wide management and demonstrates leadership in site environmental management.

This Critical Outcome is rated "Outstanding".

5.1 Sustain excellence in safety, health, and environmental protection.

Significant Achievements:

- In close collaboration with the Golden Field Office and with support from NREL senior management, NREL ES&H completed the South Table Mountain Site-wide Environmental Assessment, along with two originally unplanned supplemental field studies, at a final cost of \$117,000. This is well below the original \$150,000 cost estimate and demonstrates the effectiveness of ongoing ES&H process improvements. The

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final document incorporates lessons learned from the previous National Wind Technology Center Site-wide effort and provides a valuable resource for NREL planning processes.

Notable Achievements:

- NREL's Injury and Illness Frequency Rate of 1.36 is well below the target of 2.0, the DOE rate of 1.8, and the General Industry Rate of 2.0.
- 92% of all ergonomic cases during FY03 were resolved without additional medical treatment (surgery) or lost work days. This is a result of continued emphasis on early reporting and aggressive case management.
- The Injury/Illness Severity Rate is the direct cost incurred for medical services, lost time, etc. and is based on a DOE formula that provides an estimated cost rate for NREL and the DOE R&D Complex. NREL's rate is 4.04 cents per hour worked, which is significantly lower than the DOE average of 6.11 cents per hour worked.
- The actual Workers Compensation costs for NREL are .045 cents per hour worked. DOE and General Industry do not publish actual costs in this area. This extremely low cost demonstrates NREL's ability to aggressively manage illnesses and injuries to avoid lost work days and costly medical treatments.
- NREL continues to maintain a high training completion rate, which tracks the completion of required ES&H training requirements. For FY03 the completion rate was at 96%, which is above the metric of 95%.

Significant Deficiencies: None.

Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s): None.

5.2 Identify and implement enhanced ES&H processes, practices, systems, and tools that enable the Laboratory to better meet its ES&H goals.

Significant Achievements:

- NREL's proactive approach to identifying hazards and controls during the design phases of the Science and Technology Facility resulted in the incorporation of engineering controls during the design phase that will protect the schedule and cost during the construction of this facility. For example, the Hazard Analysis Report and the Fire Hazard Analysis were conducted in parallel with the design process and in coordination with S&TF users and the local fire authority.

Notable Achievements:

- NREL has made visible progress on the Environmental Management System (EMS) assessment and evaluation of third-party EMS certification opportunities initiated by the Lab in FY >02. During the performance period NREL evaluated available external certifications and recognitions and initiated the formal application process for the Environmental Protection Agency National Environmental Performance Track (NEPT). NEPT recognition would strengthen NREL's role in support of EERE's mission by demonstrating leadership in environmental management.
- The NREL Safety Council continues to be a valuable tool to facilitate communication from the workers to executive management and provides expert attention, through the 7 different safety panels, to specific identified hazards. NREL's Executive Management Team and Center Directors are members of and attend

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the quarterly meetings.

- The Bioenergy Center Safety Committee was established to Homogenize@ ES&H processes in the reorganized center.
- The proactive approach to the identification and implementation of rigorous electrical standards has provided a safer work environment at the NWTC while improving efficiencies (e.g., cost and timeliness) by reducing reliance on subcontractors to conduct medium voltage work. The Electrical Safety Panel conducted a comprehensive review of the NFPA 70E, *Standard for Electrical Safety Requirements for Employee Workplaces*. This review provided valuable information regarding safe work practices and the selection and use of personal protective equipment, which has been incorporated into NREL's Electrical Safety and Safe Work Permit Programs. The focus of this review was on the medium voltage operations (600 B 13,200 volts), which are common at the National Wind Technology Center (NWTC).

Significant Deficiencies: None.

Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s): None.

Critical Outcome – 6.0 Outreach and Stakeholder Relations: *MRI will build strong and productive relationships and alliances with stakeholders, advance awareness and support of the DOE renewable energy and energy efficiency mission, and advance math, science and technology education.*

The Laboratory's outreach strategy continues to bring outstanding results. Stakeholder relationships are being developed that are leading to valuable partnerships to support the EERE mission. The aggressive news media effort is bringing significant results aimed at enhancing NREL's reputation and supporting EERE's mission by providing influential national news media with accurate information about the current state, and the potential, of renewable energy and energy efficiency technologies. Local community relations efforts have shown dramatic success in enhancing the Laboratory's mission, with significant increases in visitors and high marks on visitor feedback forms. The Laboratory's education program is reaching new heights of accomplishment, reputation, and recognition inside and outside DOE because of the strategies developed and implemented over the past couple of years. Finally, communications, marketing, technology, and industry expertise provided by the Laboratory's technical communication specialists has contributed significantly to EERE's outreach mission.

This Critical Outcome is rated as "Outstanding".

6.1 Promote awareness of DOE/EERE and NREL missions and technologies, and build relationships that support the strategic directions of the Lab.

Significant Achievements:

- As part of a strategic effort by the NREL Office of Communications and Stakeholder Relations to link outreach efforts with other Laboratory efforts that encourage technology adoption and increase public understanding of energy efficiency and renewable energy technologies, the Laboratory hosted another highly successful stakeholder technology forum. The forum focused on energy and environmental management systems and attracted some 50 representatives from industry and government throughout the state, including Ball Aerospace, Gateway Computer, Conoco Phillips, EPA, and the State of Colorado. Feedback from participants ranked the forum as "best in state" on the subject. Past stakeholder technology forums on hydrogen and transportation technologies have resulted in several new collaborations between

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NREL and outside organizations to further the EERE mission.

- The above program and other, related efforts are gradually making NREL known in the region as a positive force for economic development, for attraction of high-tech companies, and for being a valuable partner in developing and encouraging the use of EERE technologies. An example of this growing reputation is the prominent role NREL played in Governor Bill Owens' Colorado Technology Summit, which included nearly 3,000 participants.
- NREL pursues a national media strategy based on four elements: developing the lab's reputation as a reliable source for information on energy efficiency and renewable energy, publicizing the availability of experts in various technologies, developing relationships with key journalists, and taking advantage of issues on the news media's agenda. Results continue to be impressive, including 600 news stories with NREL mentions appearing during this evaluation period. Major coverage included *Time*, *The New York Times*, *the Boston Globe*, and NBC Nightly News (twice). Total estimated audience reach for the print news coverage during this period is the highest ever, at roughly 130 million.
- NREL led the IEEE effort to develop the historic exhibit celebrating the 50th birthday of the modern silicon solar cell. Solar Cell #1 is highlighted in this exhibit originally having an efficiency of about 5% and still performing at its advanced age. The first module to power telephone repeaters deployed by Bell Labs in 1954-- is also on display. It has also been requested by five other professional societies and museums over the next nine months.
- Prepared and issued over 60 documents (case studies, tip sheets, technical briefs, quarterly newsletters, etc.) In support of the Industrial Technologies Best Practices activity. The impact of these documents was to promote industrial companies to take action to improve their energy usage and to improve their bottom lines.
- NREL did a superb job of combining myriad pieces of information into a resource CD of value to the glass industry. NREL was very responsive in making the CD technologically sophisticated, well organized, useful, and very user friendly.
- NREL updated and launched the Weatherization Assistance Program (WAP) website to new EERE standards. Additionally, NREL produced a State Fact sheet pilot for Kentucky and Hawaii pilot program and developed a database to track WAP programs funding and production information by year, and has developed the Build Public Education information Capability for State Energy Offices that target consumers and energy efficiency and renewable energy issues that may concern them. The educational materials pages are provided to the State Energy Office once a month from a database of educational materials.
- Roger Taylor, through his leadership in educating Tribal Leaders and Tribal Students has greatly increased the awareness of NREL, renewable technologies and EE possibilities.
- NREL has maintained close contact and good relations with the Chinese government officials in support of initiatives for the Beijing Olympics and Chinese sustainable development activities.
- NREL has supported the development of an ESCO industry in Mexico and has earned the respect and cooperation of the Mexican government.
- During this rating period NREL worked directly with OFCVT stakeholders in identifying technology targets

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for the program by taking a leadership role at the DOE/Industry Roundtable Workshop on Combustion, Emissions and Fuels. In this role NREL personnel were active in the planning phases of the workshop and chaired roundtables on issues related to advanced fuels and fuels blending agents. The discussions at these tables provided the basis for DOE to pursue new partnerships with industry.

Notable Achievements:

- NREL did a first-rate job in hosting the visit of Secretary Abraham. The visit, arranged on relatively short notice, required considerable logistical heavy-lifting to prepare for a media availability. The Secretary's staff expressed his appreciation for the extra effort the laboratory expended to make the event a success.
- Another initiative tied directly to the Laboratory's technology adoption and education mission is the Colorado Executive Outreach (CEO) program. The program involves high-level meetings between the NREL Director and senior executives of companies, NGOs, governmental organizations, and universities that have not had relationships with the Laboratory before. The Laboratory reached its goal of six meetings with new contacts this fiscal year. In the past, most such meetings have resulted in either followup visits or partnership opportunities.
- Local outreach efforts in support of the EERE mission include working with Jefferson County to determine the feasibility of using modular biomass systems to reduce the danger of wildfires and working with the City of Lakewood and Continuum Partners to encourage the use of energy efficiency and renewable energy technologies in a major urban redevelopment project. In addition to supporting the EERE mission, such notable efforts enhance the value and reputation of the Laboratory in the region.
- Indications of the success of the Laboratory's outreach efforts and its growing reputation can be seen in the positive comments made about NREL during the past few months by several members of Congress. The comments were made as part of their remarks at events unrelated to the Laboratory. Other indications are the high level of visitors the Laboratory attracted during this evaluation period, including Secretary Abraham, White House Senior Policy Analyst Tamara Jackson, EIA Chief Guy Caruso, Rep. Beauprez, corporate executives from Volkswagen, and European Parliament Member Dr. Hermann Scheer.
- NREL technical communication expertise provided valuable support to EERE. It continues to be innovative and state of the art, as evidenced by the awards the Laboratory regularly wins from professional associations. NREL won a total of four awards for its products during this evaluation period from the International Association of Business Communicators and the National Association of Government Communicators, bringing the total for the year to 21 awards.
- NCPV staff conducted a major educational exhibit at the American Solar Challenge during the stopover in Albuquerque, NM, in July. Much of the display consisted of hands-on PV equipment and applications. The complete NCPV exhibit was powered by a mobile PV array and sufficient power was produced to supply energy to other nearby exhibits as well. This biannual solar car race received significant coverage from local and national media.
- Assisted Industrial Technologies to ensure that all published documents were technically robust and accurate in support of new EERE standards in an expeditious manner.
- NREL has consistently provided technical support to OWIP's international outreach and stakeholder efforts. NREL is a key resource for maintaining personal contact and good relations in the developing countries has fallen to NREL.

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- NREL published fact sheets and case studies on natural gas vehicle user experiences. These were done with in depth knowledge derived from hands on experience obtained in helping set-up, operate, and maintain natural gas fleet activities. Two such fleets included CNG/LNG transit busses and medium duty CNG pick-up and delivery vehicles.
- NREL presented the following invited lectures:
 - "Hydrogen production from biomass" - University of Navarro, Spain
 - "Hydrogen opportunities in emerging hydrogen economy" - Mexican Petroleum Institute
 - Australian Conference on Hydrogen Economy
 - IEA Ministerial Technology Fair - NREL developed a display for the Fair, highlighting the activities of the IEA Hydrogen Agreement. The booth was visited by the Energy Ministers from the OECD, including U.S. Secretary of Energy Abraham.
 - economics of Renewable Hydrogen at the Renewable Hydrogen Forum of the American Solar Energy Society
 - Stanford University Global Climate and Energy Program. President's Hydrogen Initiative and production from Renewables, April, 2003
 - "A Vision for a Renewable Hydrogen Economy", Sierra Club Clean Energy Campaign Lecture, Boulder, Colorado.
 - "Hydrogen Overview" at Plug Power, Albany, New York. (Dr. Turner)
 - "Fuel Cells and Hydrogen", Clean Energy States Alliance Spring 2003 Meeting, Golden, CO.
 - "Photoelectrochemical Water Splitting" at General Electric's Global Research Center, New York.
 - "Renewable Energy Systems, Energy Storage and Hydrogen" at General Motors Fuel Cell Research Laboratory, Honeoye Falls, New York.
 - "Economics of Hydrogen and Fuel Cell Development", for the Denver Association of Business Economists, Denver, Colorado.
 - "A Vision for a Renewable Hydrogen Economy", Platts Global Energy Group, Boulder, Colorado.
- Provided highly technical and detailed fact sheets for input to the Fuels Technologies annual technical report.
- Several NWTC staff provided key support to the wind program's outreach and communications efforts during the rating period. NWTC staff developed and delivered several publications and related materials, including a publication called "Wind for Industry," that were extremely well received, up to and including the EE-1 Communications Office as a perfect example of "corporate" communications. Almost all of these deliverables were conceived and completed within unusually short time frames.

Significant Deficiencies: None.

Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s):

- One area of concern that surfaced during this evaluation period involved unfulfilled commitments and some apparent resistance in implementation of the 2003 American Solar Challenge outreach effort. Although the results were the best of any DOE competition to date, that success was largely due to the Golden Field Office's public affairs staff taking the extra initiative, rather than the Laboratory. Despite the Laboratory's apparent eagerness to take credit for the tremendous success of this year's event, their role in that success was less than in years past. The Laboratory needs to determine if it will continue to support the event, and if it will, to support it with the best of its ability.

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- An issue that surfaced after the end of the evaluation period involved the Laboratory's compliance with GO and EE media guidance and the EE news release approval policy. Although hopefully isolated incidents, the Laboratory needs to reinforce the importance of complying to avoid potentially high visibility problems during the politically-charged climate of an election year.

6.2 Demonstrate value as a corporate citizen within the local community.

Significant Achievements:

- The Laboratory's visitor/tour program continues to break attendance records. The total number of visitors for the past year was more than 15,300 people, a 20% increase over the previous record. One special event alone, the Consumer Energy Expo, which featured exhibits by 30 vendors of renewable energy and energy efficiency products and services, attracted some 700 people. Such efforts help make NREL a more widely known and valued member of the local area, while directly contributing to the EERE mission.

Notable Achievements:

- The first Community Leaders Breakfast held at the National Wind Technology Center (NWTC) attracted more than 40 local government and business leaders, including Rep. Mark Udall (D-CO), in whose district the NWTC sits. The event was a success. The vast majority of those attending were prominent governmental and business leaders from the Westminster, Arvada and Broomfield areas, and many had never visited the Laboratory before.
- NREL hosted a breakfast meeting during this evaluation period with the three Jefferson County Commissioners, senior County government staff, and Jefferson Economic Council. The event highlighted the strengthening relationship between NREL and the County and demonstrated the Laboratory's growing stature in the community, all as a result of a well-planned and executed outreach program.

Significant Deficiencies: None.

Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s): None

6.3 Implement programs that advance high quality science, mathematics, and technology education.

Significant Achievements:

- NREL's superior performance in hosting Office of Science-funded interns has resulted in a 25% increase in funding for 2004. NREL already saw an increase of 20% in funding for Office of Science interns hosted in 2003. In announcing the new funding increase, the Office of Science review panel said they were impressed with the number of students choosing to return to NREL (43%), the high scores for project abstracts from NREL interns (the highest of all DOE labs), and the excellent job NREL did in recruiting and recognizing mentors who support the undergraduate and teacher research programs. The panel also gave NREL accolades for overall excellence in intern program delivery and for its management of the National Middle School Science Bowl.

Notable Achievements:

- A growing reputation for superior performance in the Laboratory's educational programs, coupled with aggressive pursuit of new funding sources, has resulted in NASA funding 4 interns in 2004 and the Colorado Office of Energy Management and Conservation providing \$10K for development of educational

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materials.

- The Laboratory took delivery during this rating period of a new educational van and trailer, funded by BP America, that will be used to promote interest in science and renewable energy throughout the state. NREL deserves kudos for producing a top-notch educational resource that is certain to be very popular with schools.
- Two of the more farsighted elements of the Laboratory's education program are: (1) the emphasis placed on active participation in regional and national educational organizations to increase the Laboratory's visibility, and (2) the emphasis placed on partnerships with public and private sector entities to stretch resources and increase the programs' reach and impact. The NREL Education Office continues to develop valuable contacts and cultivate relationships across the state and beyond that are enabling the Laboratory to do far more than in the past toward increasing science literacy, inspiring interest in renewable energy, and enhancing the laboratory's reputation in the process.
- The DOE-NREL Minority University Research Associates (MURA) program subcontracts with seven minority universities to encourage minority undergraduate student interest in science and technology careers. The 5th Annual DOE-NREL renewable energy conference for minority university students was held at Arizona State University (ASU) in Tempe, AZ, in August 2003.
- A valuable addition to the national Clean Cities conference each year is ScienceFest – which was the creation of NREL staff. ScienceFest brings hundreds of local school children to the Clean Cities conference to learn about advanced transportation technologies and to engage in related science activities. It has been so successful that some communities have elected to continue the event annually after the conclusion of the conference.

Significant Deficiencies: None.

Notable Deficiencies: None.

Items of Program Interest or Concern for the Next Performance Period(s): None.

MRI's overall performance for the evaluation period is rated "Outstanding".